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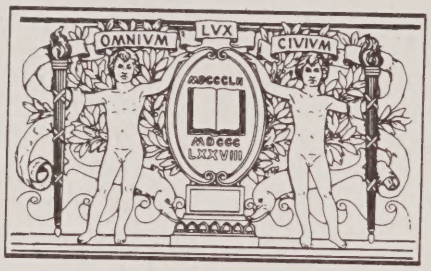

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Boston's New Economy: Medical Services and Research, Biotechnology and Other Emerging Growth Industries

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April 27, 1990

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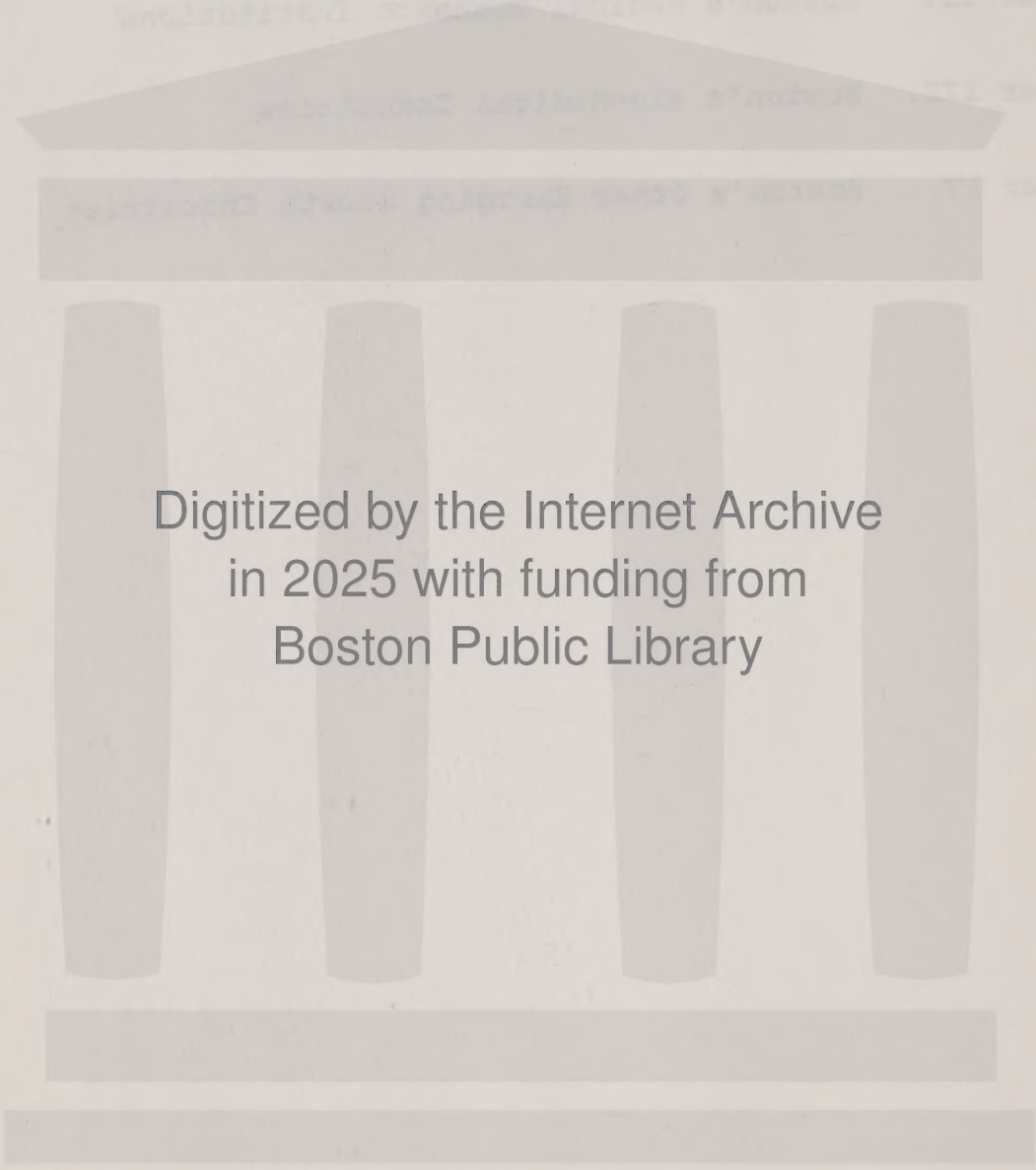

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Summary

The educational, medical and research institutions of Boston and Cambridge have been one of the keys to the prosperity enjoyed by the Boston metro area in the 1980s and in earlier decades. These same institutions are instrumental in nurturing the technology and workforce that will power Boston's emerging industries of the 1990s.

Past Economic Growth

The prosperity of the Boston metro area in the 1980s had been advanced in part by the local growth of computers and electronics companies, with the Route 128 area one of the great centers of the world's fast-growing technical industries of the past two decades. The genesis of these businesses was in the great educational institutions of Boston and Cambridge, and their growth was financed and supported by the banks, venture capitalists, and legal, professional, and business services located in Boston's downtown. These electronic and computer companies are now maturing, and have entered a period of slowing growth.

Boston's New Economy

Boston's New Economy will be driven by scientific and high technology industries and institutions. The concept and definition of the "new economy" is evolving, but at the present time it is defined as industries and activities that are based on a workforce predominantly comprised people educated in the scientific and high technology fields. Currently, new economic growth will consist mostly of medical services and medical research activities. Future new economic growth is projected to occur in the biomedical industry as well as a host of non-medical related industries such as computer software and services and the environmental fields.

Current New Economic Growth

Nationally, the demand for health care services continues to rise due to economic affluence, the demographics of an aging population, and the introduction of dramatic new technologies. U.S. employment in health services is projected to rise by an average 3.0 percent annually through the year 2000, much faster than the 1.2 percent benchmark for the overall economy. Industries that manufacture medical products are also projected to show exceptional growth, and medical products that embody the most advanced technologies will enjoy the most rapidly expanding markets.

Chapter I. Boston's Medical Service Economy

Introduction

The major component of the Boston Medical Industry is the hospital sector. The employment and labor force section of this report will discuss the hospital sector's, employment: trends, distribution, occupations, and educations; Boston residency among hospital employees, journey to work issues and the racial and ethnic composition of the labor force. The employment data for this report comes from the B.R.A., Policy Development and Research Department's, Medical Industry Survey, 1987 and the 1987 American Hospital Association Guide to the Health Care Field.

The total employment in Boston's hospitals is estimated at 54,150. This figure includes full and part time personnel. The estimated number of full time jobs becomes 43,800, when 2 part time employees are counted as one full time job or full time equivalent employee (FTEE),

Employment Trends

Total employment in Boston hospitals increased at a .82 percent annual growth rate between 1982 and 1987. The hospitals have projected a slight increase of 1.78 percent for the 1987 through 1992 period (Table 1). When 20 of the hospitals combined annual growth rates were analyzed by the type of service the hospital performed, the four community hospitals reported a slight drop in employment of .4 percent for 1982 to 1987 and predict a further decline of 2.17 percent from 1987 to 1992. Meanwhile, eleven of the specialty hospitals, and five rehabilitation, chronic

(Table 3). The West End of Downtown Boston is the site of 12,200 jobs or 22.5 percent of the hospital labor force. There are 8,580 hospital workers south of the downtown in the South Cove/South Bay area which amounts to 15.8 percent of all hospital employees. Jamaica Plain is host to 4,270 hospital employees or 7.9 percent of the total. Brighton has a concentration of four hospitals that employ 3,231 workers which is 5.9 percent of the city's hospital labor force. The remainder of the hospital employees are scattered throughout the City in the neighborhoods of Dorchester, Roslindale, Roxbury, West Roxbury, and on Long Island in Boston Harbor. These nine city-wide hospitals contain 7,735 employees and consist of 14.2 percent of the hospital labor force.

Boston Residency

The percent of the Boston's hospital labor force that resides within Boston is an astounding 48 percent. This ranges from a high of 100 percent for Boston City Hospital, which requires employees to become Boston residents, to a low of 22.5 percent. The averages also vary by the type of hospital, for example, community hospitals are above average with 64 percent of the total labor force residents of Boston. The rehabilitation, chronic disease, and psychiatric hospitals are slightly lower at 60 percent. While the specialty hospitals are below the city average with 43 percent.

Journey To Work

There are an estimated 31,000 hospital employees that commute to Boston. The Metro-West communities contribute 10,900 employees or 20 percent of Boston's hospital labor force. The South Shore exports 7,450 hospital employees to Boston, which is 14 percent of

Car-pooling arrangements involve a surprisingly high 7,500 or 14 percent of the hospital employees. One reason for this high percentage, is that eleven of the hospitals have a carpool or vanpool program. The participation rate for each medical institution varies from 2 percent to 15 percent of employees.

Walking or biking to work is an option that 5 percent or 2500 hospital employees exercise.

An employer provided shuttle ferries 1.4 percent or nearly 800 hospital employees to their jobs from satellite parking lots or from public transit stations. The remaining 3.6 percent or 2,00 employees, used other means of transportation or were unclassified.

CAREER OPPORTUNITY AND STAFFING NEEDS IN BOSTON HOSPITALS

Boston hospitals and health service industries are world and national leaders in patient care, education, and research. They are also economic leaders within the city. In 1986, private (non-government) health services and public hospitals represented 12.4 percent of all permanent jobs located in Boston. Of these 75,378 jobs, 47,862 were in thirty one hospitals. Even more important to us today is the opportunity for immediate and future employment gains in this sector. In a survey conducted last year by the Boston Redevelopment Authority and in reports to the Massachusetts Department of Public Health, these hospitals indicated a five percent staffing shortfall representing 2,274 openings. Table 7. The B.R.A. survey revealed an additional 2,360 jobs anticipated in these hospitals by 1992.

The greatest numbers of current employment opportunities are in nursing (979 positions to be filled), nurses aides and orderlies

The better jobs require education or training beyond the high school level. High school education or equivalency, with the literacy, basic science background, and motivation to go further are likely to be rewarded in this field. Boston colleges and hospitals have scholarships available to city residents that are going unused due to a lack of interested and qualified candidates.

The economic environment is requiring Boston's great hospitals to search for new and effective ways to inform, motivate, train, and recruit their future staffs. Now is the time for us to join with them in new partnerships to realize the value that Boston's people and hospitals can find in one another.

Table 1: Hospital Employment and Growth Rates
By Type of Hospital, 1982, 1987 & 1992

Type of Hospital	Number of Cases	1982 Employees	1987 Employees	1992 Employees	Annual Growth Rates 1982-1987	Annual Growth Rates 1987-1992
General	4	8,168	8,005	7,172	-0.40%	-2.17%
Specialty	11	27,163	28,458	32,541	0.94%	2.72%
Rehab, Chronic or Psychiatric	5	2,000	2,422	2,755	3.90%	2.61%
Total	20	37,331	38,885	42,468	0.82%	1.78%

Source: Boston Redevelopment Authority, Policy Development and Research Department, Medical Industry Survey, 1987.

Prepared By: M.R.J., 2.5.88., GROWRATE.WK1

Table 2: Hospital Employment By Type of Hospital
For Selected Years 1982, 1987 & 1992

Type of Hospital	Number of Cases	1982 Percent	1987 Percent	1992 Percent
Community	4	21.9%	20.6%	16.9%
Specialty	11	72.8%	73.2%	76.6%
Rehab, Chronic & Psychiatric	5	5.4%	6.2%	6.5%
Total	20	100.0%	100.0%	100.0%

Source: Boston Redevelopment Authority, Policy Development and Research Department, Medical Industry Survey, 1987.

Prepared By: BRA, PDR, M.R.J. 2.5.88. HOSPTYP2.WK1

Table 5: Employees Origin of Commute

Area	Employees Sample=13	Employees Universe=31	Percent Sample=13
Boston	9,117	23,183	42.8%
Inner Suburbs	3,164	8,045	14.9%
North Shore	1,610	4,094	7.6%
South Shore	2,951	7,503	13.9%
Metro-West	4,317	10,976	20.3%
Other	292	742	1.4%
Total	21,292	54,143	100%

Source: Boston Redevelopment Authority, Policy Development and Research Department, Medical Industry Survey, 1987.

Prepared By: M.R.J., 2.5.88, NONBOST.WK1

Table 6: Hospital Employees, Journey To Work, 1987

Mode of Transport	Employees (Sample) N=21	Employees (Universe) N=31	Percent Distribution
Public	11,061	14,214	26.3%
Private	21,040	27,037	49.9%
Shuttle	600	771	1.4%
Carpool	5,841	7,505	13.9%
Walk/Bike	2,055	2,641	4.9%
Other	1,538	1,976	3.6%
Total	42,135	54,143	100%

Source: Boston Redevelopment Authority, Policy Development and Research Department, Medical Industry Survey, 1987.

Prepared By: M.R.J., 2.5.88.,Journey.WK1

Chapter II. Boston's Medical Research Institutions

Medical research is conducted in the City's seventeen research hospitals, five non-profit research institutes and three medical schools, for a total of 25 Medical Research Institutions (MRIs) in Boston.

The mission of the Boston Redevelopment Authority (BRA), Policy Development and Research Department (PDRD), is to conduct research on the Boston economy and the demand for real estate in Boston to provide information to the agencies institutional and neighborhood planners. It was for this reason the BRA, PDRD conducted a Medical Industry Survey, in 1987-1988. The survey concentrated on the hospitals since they are the largest sector of the medical industry. In this paper, an analysis of the hospital survey results is presented; focusing on the existing supply and future demand for medical research space, employment, and funding.

Institutional Demand for Medical Research Space

There is a total of 2.6 million square feet of research space housed in the 25 medical research institutions. The MRIs collectively have expressed a demand for 2.92 million square feet (s.f.) of new research space over the next several years. Hospitals and medical schools have submitted plans and proposals to the BRA for 2 million s.f. of additional research space. A further demand for 896,000 s.f. research space was also reported by hospitals and non-profit research institutes in the BRA, Medical Industry Study, but has not yet appeared in any specific project proposals from the institutions. Table 1.

Location of Future Medical Research Facilities

The demand for medical research space may be met by expanding either on-campus, such as Children's Hospital has done with the completion of an expansion to the Enders Research Building by adding 142,800 square feet (s.f.); or by expanding off-campus, such as Massachusetts General Hospital has done in the 600,000 s.f. Lawrence E. Martin Laboratory in Building 149 at the Charlestown Navy Yard.

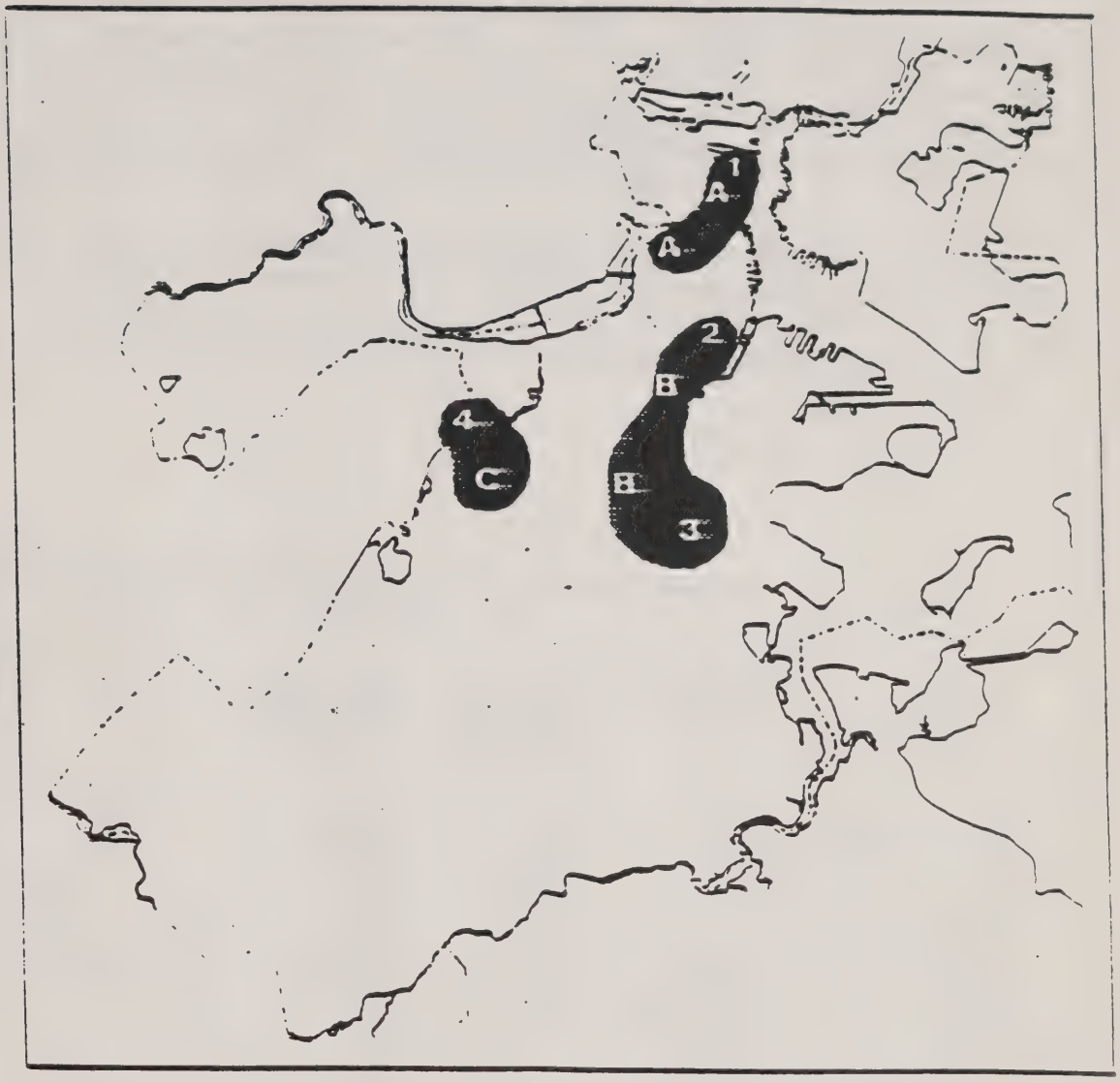
The BRA's January 1990, Master Plan for Yard's End, which is part of the Charlestown Navy Yard, envisions up 1.1 million s.f. of additional research space with a potential addition to Building 199 of up to 200,000 s.f. and a new medical research new buildings adding up to 900,000 s.f.

Other off-campus expansion sites in the vicinity of medical research areas include Olmsted Plaza, which is located on the fringe of the Longwood Medical Area as well as Boston Science Center, South End Technology Square and South Station Technopolis, which are located in the South Cove-Newmarket Research Area. See Map.

While some of the medical research institutions have submitted plans for on-campus expansion or development of research facilities, these plans may change as other the options become available, such as the development of attractive off-campus facilities.

Geographically, the institutional research space is concentrated in three areas. The current and future centers of research activity are shown on the map.

BOSTON TECHNOPOLIS CENTERS



Medical Research Areas

A: West End/Charlestown Navy Yard
B: South Bay/Newmarket
C: Longwood/Fenway

Medical Research Centers

1: Building 149
2: South Station Technopolis
3: Boston Science Center
4: Olmsted Plaza

Medical Research Area

estimated to expand by between 52.5 percent and 82.2 percent depending on how densely the new space is allocated. The reason for the disparity between the growth rate of space and employment is the hospital are now experiencing "overcrowding" and the expansion of space will relieve this condition as well as increase the research capacity.

The average salaries for all research occupations is $32,300, ranging from $15,013 for the janitorial staff to $66,875 for medical doctors. The estimated total payroll for all institutional research in Boston is $254 million annually. See Table 2. The large disparity between average salaries for research occupations can be explained by the difference in educational attainment levels and skills required for the jobs. There are basically three levels of research employment and they are distinguished by there educational attainment/skill levels.

The highest level is for professionals and requires an advanced college degree. There are an estimated 3,541 professionals, some 45 percent of all research employment. The occupations included in this category are research scientists, medical doctors and some administrators. The average salaries for the professionals is $44,973 with an average range of $29,410 to $66,875. Table 3.

Table 2: Hospital Research Employment, Average Salary and Payroll by Occupation, 1989

Occupations	Percent Employed Weighted	Medical Research Employment	Average Salary	Estimated Payroll
Research Scientists	34.5%	2,718	$36,622	$99,530,349
Doctors	12.5%	983	$66,875	$65,712,563
Laboratory Techs	26.4%	2,079	$21,778	$45,276,769
Computer Techs	1.3%	106	$22,957	$2,434,490
Administrators	5.5%	431	$29,410	$12,671,815
Secretary/Clerkical	14.7%	1,160	$18,355	$21,285,794
Janitorial Staff	1.9%	150	$15,013	$2,256,286
Other	3.1%	243	$21,000	$5,096,257
Total	100%	7,869	$32,300	$254,264,323

Note: Occupational data obtained from 12 of the 17 research hospitals.

Employment data from Table 1.

Average salary obtained from 12 of the 17 research hospitals.

Source: BRA Research Dept.,Medical Industry Survey, 1987.

In the BRA, Medical Industry Survey, the hospitals were asked a series of questions about the location of the needed research space.

Fourteen hospitals report that the location of their needed research space should be near the main facility. Eight of them feel that the new space should be within "walking distance", four believe that any new space should be on-campus, and one hospital wants any new research facility to be within a 15 minute shuttle ride.

These same 14 hospitals rated 8 criterion for locating research space. The single most important criteria for locating research space is "proximity to hospital". The second rank is tied between "proximity to patients" and "proximity to other labs in hospital". Ranked third is the demand for floor loading capacity of 100 lbs. per square foot. There is also a tie for fourth rank between "availability of parking" and the "ability to share clerical and technical staff". The fifth rank is tied between "access to public transportation" and the "ability to access existing computer facility".

There were also 10 hospitals that responded to having a location in mind for their possible expansion. These 10 hospitals gave 14 possible locations which include, seven that would either expand on-site or at a site adjacent to the hospital, two are thinking about the Charlestown Navy Yard, one each mentioned the following: Emmanuel College, Science Museum Area, South End Technology Square, and South Station.

Finally, when the hospitals were asked if they would consider the Charlestown Navy Yard, Parcel 18 near Ruggles Station on the Orange Line, South End Technology Square, and the Sears Building on the Fenway the following responses were given:

Charlestown Navy Yard	7
Parcel 18	8
South End Tech. Square	5
Sears Building	9

The hospitals that identified a location tended to be situated in a nearby medical area. Out of the 7 research hospitals that would consider the Charlestown Navy Yard, 4 are West End institutions. Four of the Longwood Medical Area institutions would consider Parcel 18 and six would consider the Sears Building as suitable locations. The South End Technology Square site was considered by five of the medical institutions two of which were adjacent South Bay hospitals.

The hospitals were asked a series of questions aimed at describing the their existing research facilities.

Out of the seventeen hospital with a existing research facility answering the BRA Survey in 1987-1988, ten of the hospitals had their own separate facilities, 6 had combined facilities with other hospitals and 1 hospital has both separate and combined facilities.

Twelve of the hospitals performed research on-site only, and five hospitals that conducted research both on-site and off-site.

All 17 hospitals own most of their research space and altogether 85 percent of the space was owned. However, four hospitals rented between 20 and 44 percent of their research space.

the universe of the 17 hospitals with great confidence.

The existing full time equivalent employment numbers in the following section were provided by 15 of the hospitals and estimated for two hospitals by dividing existing square footage of research space by 325.31 s.f. per ftee. This same method was used for all existing space in the medical schools. The non-profit research institutes provided all the necessary existing employment data.

There were a total of 15 hospitals that expressed a desire to add space and employment. Only six of these hospitals or 40 percent provided information on both their anticipated space and employment needs. These six hospitals are expecting to add a total of 305,400 s.f. but only 397 employees. This results in an average of 769.27 s.f. per additional employee, which is more than double the present 325 square feet for existing employees. This reveals a pent-up demand for research space due to overcrowded conditions in the existing supply.

Once these hospitals add their anticipated space and employees, the resulting square footage per employee in these six hospitals if the needed space is developed and the additional employees are hired is 473. This number is assumed to be the "optimum" amount of space per full time employee in the research facilities.

The future hospital and medical school research employment was calculated in two ways to provide low and high estimates. The low method summed up the existing and future space, divided that number by the "optimal" staffing level of 473 s.f. per ftee and then subtracted the existing employment to reveal the additional employment needed to bring existing and future space up to the optimal level. The high method assumed no change in existing space and new space would all be staffed at the "optimal" level of 473 s.f. per ftee.

The non-profit research institutes future employment requirements were calculated by staffing future space at the existing 429 s.f. per employee level.

Institutional Demand for Research Personnel

There are approximately 7,869 full-time equivalent (fte) jobs accommodated in the research space occupied by the medical research institutions in Boston. The future research space would accommodate between 4,131 and 6,469 new fte research positions depending on how densely the staff occupies new and existing space. Nearly half of Boston's employment in medical research is located in the Longwood Medical Area, which contains 3,558 employees. The space needs expressed by the Longwood MRIs will house between 1,523 to 2,497 new employees. The West End-Charlestown Medical Area contains an estimated 2,218 research positions, 28 percent of the City's total, and the new space required would accommodate between 716 to 1,253 new positions. The South Cove-Newmarket Medical Area now has 1,861 research jobs, which is 24 percent of the City total, and future space needs will accommodate between 1,765 and 2,518 new research jobs. Other hospitals in the City employ 232 research workers, which is 3 percent of the total. They expect to hire between 128 and 201 research workers in the future.

In 1987, the total full-time equivalent employment in the hospital research sector was estimated at 6,046 full time equivalent employees. This was 12.6 percent of the total hospital full time equivalent hospital workforce of 47,862.

While research space is projected to increase by 112.8 percent research employment is

Another source of funding for basic research is the National Science Foundation (NSF), which, along with NIH, will be disbursing $3 billion throughout the 1990s for the Human Genome project. This project aims to map the human genetic structure and has captured the imagination of the current Congress similar to the way the space program captured the imagination of Congress in the 1960s.

Corporate Sponsored Research Agreements

The private funding of medical research has advanced in the 1980's with two mega-deals between Massachusetts General Hospital and two large international corporations.

In 1980 University of California, San Francisco (UCSF), molecular biologist Howard Goodman approached the West German firm Hoechst A.G., a major chemical company, with a proposal that the company fund him and selected colleagues in exchange for the opportunity to licence and develop discoveries resulting from the research. Hoechst pledged $70 million, which Goodman took to Massachusetts General Hospital (MGH) when UCSF's bureaucratic procedures proved too impenetrable for him to deal with. The final arrangement was made in 1981 between MGH and Hoescht A.G., for $68 million. When this deal was announced, the news sparked a congressional hearings and landed the hospital in a nasty battle over release of its contract with the firm. Tennessee Congressman Albert Gore, Jr., questioned whether foreign companies were indulging in a sophisticated way of skimming the cream produced by decades of government-supported research when they sign agreements with research institutions. One result of this furor was, when the Hoescht agreement was drafted, the hospital promised researchers covered by it would no longer seek federal funds. The research itself has focused entirely on basic science that has not produced a single patentable discovery in more than eight years of work.

By contrast, when MGH announced a second multi-million dollar corporate-sponsored research agreement in the summer of 1989 with the Japanese cosmetic firm Shiseido it barely caused a stir. This is the nation's largest corporate sponsored research agreement, in which MGH receives $85 million plus royalties on Shiseido products based on discoveries emerging from the research. Dr. John A. Parrish, the engineer of the partnership agreement says that he expects company-funded scientists to raise another $17 million to $27 million in government and foundation grants over the next decade. Although researchers will have the right to chose projects - regardless of whether they help the company - hospital officials expect to make some discoveries that can be patented and licensed to the company for products within a few years. The research agreement will support a 100 person skin research center at MGH's Charlestown Navy Yard facility.

In February 1990, MGH announced its first corporate sponsored research agreement with an American pharmaceutical company. Bristol-Myers Squibb Co. has entered into a five-year agreement for $36.8 million with MGH, to establish a cardiovascular research center in the Charlestown Navy Yard. The research center will occupy some 50,000 square feet and employ as many as 100 new employees. The pharmaceutical firm will receive first rights to develop any new products that result from the research.

The current outlook for Boston's medical research institutions is for a very healthy future. The Massachusetts and Boston metropolitan area economies will benefit as the hosts to new biotechnology firms that will undoubtably be generated from all this research activity. The next section will address the future outlook for the private biomedical, biotechnical and other emerging industries.

Chapter III Boston's Biomedical Industries

Biomedical industries are a broadly defined in this report as the medical-related products of genetic and cell engineering, more commonly referred to as biotechnology, as well as traditional pharmaceutical, medical instrumentation, devices and equipment. These industries are frequently cited as having "special potential as sources of economic growth" or as a "new engine for the economy".

The increasing demand for new and existing biomedical products is a result of the worldwide increasing demand for health services. In the US, there was a 10-percent increase in hospital employment between 1986 and 1988, after seven years of virtually no growth. This indicates that the pressures of rising demand for hospital services may eventually have to be accommodated. Demand pressures stem from several factors, some of which are expected to intensify in the future: "new medical technologies", a rapidly growing aged population, and treatment of AIDS patients.

New technologies are the most important factor in boosting demand for health services. Because of advances, patients are likely to undergo more tests and diagnostic procedures, take more drugs, see more specialists, and be subjected to more aggressive treatments than before. Medical intervention will be possible for conditions previously undiagnosed or regarded as untreatable. The use of sophisticated and expensive new equipment, labor intensive acute care, and multiple doctors' visits and lab tests is bound to accelerate.[1]

Biotechnology

Biotechnology is generally defined as any technique that uses living organisms or products derived from them to make or modify products. The majority of biotechnology research spending or 69 percent in 1987 went toward health care products (See Chart).[2] Therefore the demand for biotechnology products is dependent upon the future demand for health care which is projected to

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[1] Personick, Valerie A. "Industry output and employment: a slower trend for the nineties." Monthly Labor Review, November, 1989, page 29.

[2]. David L. Wilson. "Race for Biotechnology Dominance Takes Off", National Journal, May 20. 1989.

Perspective". Professor Joyce Tait, of the Open University, addressed the European perspective on the attitudes and regulation of the biotech industry, many of her points are summarized below.

In the history of regulating substances that could potentially harm the environment, regulations have mostly been reactive. An example of reactive regulation is the pesticide DDT which was heavily restricted after destroying wildlife.

A second way of regulating substances is to be proactive, this was the approach the City of Cambridge took when it passed an ordinance regulating the research of recombinant DNA more strongly than the National Institutes of Health. Some European countries have also adopted this proactive approach to regulating the biotechnology industry.

Ms. Tait described the European attitudes opposing biotechnology as having two magnitudes. One was the NIMBY view which stands for not in my back yard; this is the view of the biotech opposition in the United Kingdom. This views a biotech plant as a locally unwanted land use which makes it possible to overcome oppostion by selecting an uncontroversial site.

The second type of opposition is the NIABY which means not in anyone's back yard; this is the type of biotech opposition that exists in West Germany. This is position that the West German Green Party has developed.

The Greens are a West German political party with a great concern for environmental issues which includeds opposition to the manufacture of biotechnology products. An example is a Hoechst human insulin fermentation plant which is built and ready to operate but has been halted by a court order which is pending appeal. Hoechst has vowed to fight [...however, another West German firm BASF has chosen to avoid a confrontation and has moved its biotechnology operations to the Worcester Biotechnology Park].

The Green party is becoming popular in other European countries and may soon emerge as a power in the Netherlands.

The backlash to the Greens activity is a scientific and business group which has formed to fight for laws favoring progress in science such as research and production of biotechnological products.

There are two major approaches regulating the biotechnology industry. The first is product-based approach which is used in the United States to regulate biotechnology products which must be approved by the Food and Drug Administration (FDA).
The second approach is to regulate the biotechnology process, which involves applying for permission every time the biotechnology process is used; justifying the use of the process so that no unneccessary experiments are conducted which could endanger the welfare of European inhabitants; this gives tremendous power to regulating authorities; and creates a burden on biotechnology firms.

If the Europeans continue with a process based approach and the United States continues with a product based approach then the US will have an advantage over the Europeans. If US regulations are less restrictive then products are less costly to develop in the US. European biotech firms will either have a cost disadvantage or they will have to move their research and production facilities to the US...[like BASF has done].

The Soviet Union and Eastern European Biotechnology

The Soviet Union and Eastern Europe are important in biotechnology both as players with technology being developed in the Soviet Union and other Eastern Block countries as well as a market for product developed in the West. An example of both Soviet technology and the market for Eastern Europe are found in the following article.

> A Soviet research institute would trade technology for an equity stake in a US biotechnolgy company under a proposed deal that could mark a new form of Soviet-American business relations.
>
> Under the plan, the Institute of Protein Research outside Moscow will swap protein synthesis technology for a 5 percent to 20 percent ownership stake in Transgene Inc., a Silicon Valley start-up specializing in protein synthesis.
>
> The Soviets have developed a new way to create proteins like insulin that cut the development time from weeks to days or even hours.
>
> The plan would form one model for how US venture companies can invest in and commercialize promising new technology in the Soviet Union.
>
> The plan still needs approval by the US and Soviet government but if approved, Transgene will be allowed to commercialize the technology and sell it to all but Eastern European countries. The technology would be transferred back to the Soviet institute for sale to those countries.
>
> Under the arrangement, the Soviets would get an opportunity to learn firsthand how to bring technology from the research lab into the commercial world.
>
> The US Commerce and Treasury Departments are expected to become involved in the approval process because the joint venture would involve a transfer of technology in both directions.[6]

U.S. Biotechnology Industry

There are about 500 or so newer biotechnology firms in the US, that were founded after 1975 (1980-84 were the peak years). More than 200 manufacturing firms have diversified into biotechnology. Their level of commitment varies from technology monitoring to in-house research, contract research at biotechnology firms and universities, investing in and aquiring specialty firms and joint ventures. An additional 300 firms (one-third founded in the 1980's) supply material,

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6. "US-Soviet biotech venture proposed", Boston Globe. December 11, 1989.

Biotechnology Research and Development

The federal government has played a major role in stimulating the biotechnology industry. In 1987, the federal government invested $2.7 billion in biotechnology research and development (R&D) which was 63.5 percent of total spending and nearly twice the amount spent by private industry (Table X).

Biotechnology Research
Funding by Source, 1987

Source of Funding	Funding B=billion M=million	Percent From Each Source
Federal Government	$2.7 B	63.5%
Private Industry	$1.4 B	33.0%
Thirty-three State Governments	$150 M	3.5%
Total	$4.25 B	100%

Source: U.S. Industrial Outlook, 1990
Prepared by: BRA, Policy Development and Research Dept.
M.R.J. 3.21.90. (biofund.wk1)

** Possible Pie Chart**

Federal government research money is dispersed by the National Instituites of Health (NIH) and the National Science Foundation (NSF). The discovery of recombinant DNA techniques, for example, was a direct result of a the Federal Government's support for health research during the past several decades.[8] Currently, and in the future, the Federal Government's increased funding of research to decipher the human genome will play an important role in creasing our knowledge of the biochemistry of life.[9] This research will provide a road map that will pave the way to future product development in the biotechnology industry, in a similar fashion to the way the US Interstate Highway System paved the way for the US auto industry to develop in the 1950's and 1960's.

Many firms in the biomedical industry especially the newer biotechnology firms depend on the laboratory facilities of major academic institutions for developing their products and processes.

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[8] US Industrial Outlook, 1990, page 20-2.

[9] US Industrial Outlook, 1990, page 20-4.

probes. Some examples of the current uses for diagnostic kits using monoclonal antibodies or DNA probes are: diagnose pregnancy & fertility, bacterial and viral infections; DNA fingerfrinting; and genetic diseases.[11]

Bio-therapeudics require long lead times for both development of new products and regulatory approval, which has traditionally taken 7 to 10 years for new drugs. There are presently only 10 bio-therapeudics on the market. The are an additional 80 bio-therapeudics in testing stages (See Table and Pie Chart). An example of a bio-therapeudic is human insulin, until recently most insulin came from the processing of pork bellies, however, a small percentage of diabetics were allergic to pork insulin, now human insulin is manufactured using biotechnology, this breakthrough has been most beneficial to the diabetics that were allergic to the pork insulin but are not allergic to the human insulin.

Bio-Therapeudics In Testing Stages, 1989

Treatment Or Uses	Number	Percent
Cancer	45	56%
AIDS	14	18%
Other	21	26%
Total	80	100%

Source: Pharmaceutical Manufacturers Association, Washington D.C., 1989.
Prepared by: BRA, MRJ 4.3.90 (biotest.wk1)
Insert Table & Pie Chart

A sizable portion of this research money -31 percent or nearly one-half billion-, was spend on non-healthcare related biotechnology which includes plant agriculture (13%), animal agriculture (8%), chemical and food additives (5%), and all other research (5%) or biosensors, environmental cleanup, and energy.

Plant agriculture research captured 13 percent of all private biotechnology research funding or $180 million. In plant agriculture biotechnology is providing tools to develop new crops with improved resistance to pests, diseases, herbicides, pesticides, and environmental stresses and to

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[11] U.S. Industrial Outlook, 1990. Page 20-2.

developments in biotechnology. An example of this investment is the North Carolina Biotechnology Center which was established in 1985 is the oldest state program in the nation. The Biotechnology Center supports the work of 200 university scientists and 35 new biotechnology companies with grants. The center has awarded several research grants worth nearly $200,00 to Embrex Inc., an engineering and research company that is developing an automated machine to administer booster shots to unhatched chicks. Engineers have developed a machine that punches holes and injects vaccines and proteins into 148 eggs at a time. Embrex executives say that poultry companies are eager to buy the new machine because most of the 5.5 billion chickens produced in the United States each year are vaccinated by hand just after they hatch in a process that is expensive, and often lethal to the chicks.[13]

New England Biotechnology

In New England, a region with few natural resources, the economy has prospered by developing innovative uses of technology derived from the regions academic and industrial research centers. The biotechnology industry is linked to these institutions and especially to the academic medical centers in which region has a unique concentration.

> An important new segment of the biomedical industry are therapeutic and diagnostic agents created by the biotech firms using genetic and cell manipulation. Examples are human growth hormone, human insulin, hepatitis B vaccine, and quick tests for strep throat and diabetes. The New England biotech industry consist of 85 firms, 50 in the Boston area alone and others scattered throughout the region, which are typically younger and cover a broad range of new products and services.
>
> Although some are engaged in research relating to agriculture or environmental clean-up, most of the biotech firms in the region are concentrated on projects that have medical/pharmaceutical applications.[14] Many of New England's biotech firms are newly-formed, small innovative companies --whose yield in economic "dividends for the region, though largely long-term, hold significant potential.[15]

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[13]. Schneider, Keith. "States Spurring Outlays In Biotechnology Field", New York Times, Feb. 18, 1989.

[14]. As noted in the study, Biotech 88: Into the Marketplace, conducted by the Arthur Young High Technology Group, the large pharmaceutical industry nay be transformed by the techniques of biological manipulation being perfected by small biotech companies.

[15] New England Board of Higher Education, Commission on Academic Medical centers and the Economy of New England, Biomedical Research and Technology: A Prognosis for International Economic Leadership, June, 1988. Pages 6-7.

Massachusetts Biotechnology

A new generation of technical-based growth industries is emerging from institutions in the Boston metro core. The educational, medical and research institutions are now not only carrying out basic research in the biotechnical and medical fields but they are generating a number of spin-off private companies. The number and size of these new companies are expanding rapidly, although from a small current base.

The private biotechnology drug industry is quite small, representing 0.02 percent (2 percent of one percent) of national employment in 1987, but it is also growing rapidly, with national employment increasing at a 9.5 percent annual rate between 1984 and 1987. Massachusetts does have a concentration of biotechnology firms and employment, showing the state's comparative advantage. Within Massachusetts, 86 percent of the state's biotechnology employment was in the Boston metropolitan area in 1987, according to the U.S. Dept. of Commerce.

The State of Massachusetts, Governor's office January, 1990 report titled, "Winning the Nineies: An Economic Strategy for Massachusetts", describes biotechnology as, "a new engine- an industry, that holds promise of rapid growth in manufacturing as well as R & D, which has the power to spin off many times its weight in derivative jobs.

According to the report, Massachusetts goal for the 1990's is to become a world center for biotechnology, biomedicine, and related industries, with the state leading in manufacturing as well as in research.

The report backs up the claim for explosive growth of the biotechnology industry in the 1990's by citing a number of real estate and business developments that have occurred in the recent past including; Worcester Biotechnology Park, BASF, Elsai Institute, and numerous other corporations.

The Worcester Biotechnology Park (WBP), which was founded in 1981 by the Worcester Business Development Corporation, which is a subsidiary of the Worcester Chamber of Commerce. The park occupies a 75 acre site adjacent to the University of Massachusetts Medical Center on the outskirts of Downtown Worcester. At build out the park is intended to have 1.1 million square feet of research, production, office and service space.

The first way is to develop a science friendly business climate by working with industry leaders to press for sensible regulation at the local level (genetic research ordinances) and national level (commercialization of discoveries in institutional laboratories). Work to establish an FDA office in Boston. Work with local communities to "pre-qualify" biotech manufacturing sites. Work with biotech community to establish a shared facility for "Good Manufacturing Processes" --the production testing that new biotech products must undergo.

The second set of steps the state can take are for education and training. The Bay State Skills Corporation has committed $400,000 over the 1990-1991 period to match biotech firms in a partnership to train high school teachers in biotechnology and fund a one-year, post secondary certificate program in biotech research and manufacturing skills for entry level workers.

While the state has taken some positive steps toward biotech education some negatives moves were made as well as pointed out in the following excerpt of a letter to the editor of the Boston Globe.

> One result of a law approved in July 1988, is the tax exemptions on graduate student stipends and employer provided education assistance were removed. Much of the university research upon which biotechnology depends requires graduate students to do the work. Creating this graduate study disincentive not only threatens biotechnology research productivity, it will also reduce the pool of qualified entrepreneurs and faculty needed to sustain the economic machine. There is currently a bill before the Legislature that would reinstate this education tax incentive.[18]

The state will work with the Massachusetts biotech community to promote the state as a world capital in biotechnology. This effort will include new jointly-developed marketing materials and direct appeals to companies in other states and overseas to establish facilities and joint ventures in Massachusetts.

The state will work with the Greater Worcester biotech community to plan a second biotechnology park, perhaps on a portion of the former Grafton State Hospital grounds where the Tufts -New England School of Veterinary Medicine is located. The current budget crisis is threatening the Tufts New England School of Veterinary Medicine which in turn is threatening a number of biotech firms that use the school's facilities to conduct research as the following article

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[18]. Waggaer, David, MIT Dept. of Chemical Engineering. "Biotech article minimized the importance of education", Boston Globe, January 2, 1990.

The Hoffmann-La Roche offer will immediately inject $500 million worth of cash into Genentech, which is almost as much as the biotechnology firm has raised since its inception.

The Swiss company gains access to Genentech's undisputed research and development prowess, commands a controlling 60 percent interest, with an option to buy the remaining 40 percent at an already agreed price.

Now that Genentech has been taken over, experts are predicting a wave of takeovers in the biotechnology industry. This is highly possible for a few larger firms --Cetus, Centocor, Amgen--but unlikely for most biotechnology companies, which have little to offer a buyer but a few prestigious scientists, whom big companies will find it cheaper to lure away separately than to pay a hefty price for a struggling company. Rather than look for a buyer, most biotechnology companies will try to make the most of a role many have already assumed: as research boutiques working on behalf of traditional pharmaceutical companies who have the financial muscle and large staffs needed to develop and market their ideas. Biotechnology has plenty to offer, but not, it seems, entrepreneurial excitement.[20]

Pharmaceuticals

The Eisai Institute, the American R & D arm of Japan's principle pharmaceutical houses, has opened a research facility in Andover.

* Johnson & Johnson has established its medical instruments group headquarters in Raynham.

* The medical instruments division of Hewlett-Packard, continues to grow at its Andover and Waltham facilities.

In 1988, world drug sales were $50 billion (including exports and products made abroad) and US multinationals made 40 percent of those sales.[21]

In 1983 for the third year in a row Japan led the world with the largest number of new drugs brought to the market. The number of new American drugs has fallen 50 percent from the levels of the mid-1960's.[22]

Orphan Drugs

In 1983 Congress passed the Orphan Drug Act to promote the development of drugs to treat

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[20]. "Test-tube trauma: The sale of Genetech", The Economist, February, 10, 1990. Page 67.

[21]. U.S. Industrial Outlook, 1989.

[22]. "Japan Is Top Drug Developer for Third Consectutive Year," Japanese Economic Journal, Feb 7, 1984 page 15; Harold M. Schmeck, Jr., "Report Says Japan Could Lead in Commercial Biotechnology," New York Times, Jan. 27, 1984, page A9; Lester C. Thurrow, Zero Sum Solution, Simon & Shuster: New York, 1985, page 56.

researching that drug (being close counts in the orphan drug industry). The major question remaining is what if the market for this drug was much smaller than the estimated $300 million would the judges have asked each company to share the pie if the pie had been much smaller. This case sets a precident for the orphan drug industry that could have positive as well as negative effects on the future research and development of orphan drugs that may depend on the total size of the market for those drugs.

Medical Instruments

In New England, the medical instrumentation sector represents a significant part --$2 billion-- of the biomedical industry. Twenty percent of total U.S. sales of biomedical instruments (such as intensive care and fetal monitors, defibrillator, X-ray and surgical devices) are sold by New England manufacturers.[25] In the medical equipment industry, the U.S. trade surplus increased to $1.2 billion in 1988, despite deficits with West Germany and Japan. One-third of US revenues in the medical equipment industry was from exports in 1988, and exports rose 22 percent in 1988 to $3.9 billion.[26] Allied with the biotechnology drug industry is the medical instruments industry, which is presently nearly 10 times the size of Biotech (S.I.C. 2831) and which is maturing as a strong New England and Massachusetts complete industry (research, administration, and manufacturing). Twenty percent of total U.S. sales in biomedical instruments (such as intensive care equipment and fetal monitors, and laboratory equipment) are sold by New England manufacturers. Massachusetts has double the national level of employment concentration in this industry, and 80 percent of the state's medical instruments employment is in the Boston metropolitan area.

The more mature members of the biomedical portfolio are increasing their production workforce as products developed in research laboratories are entering the marketplace.

> In the US medical instruments and surgical appliances industries the production workforce increased to 63 percent in 1988.[27]

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[25] New England Board of Higher Education, Commission on Academic Medical centers and the Economy of New England, Biomedical Research and Technology: A Prognosis for International Economic Leadership, June, 1988. Pages 6-7.

[26]. U.S. Industrial Outlook, 1989.

[27]. U.S. Industrial Outlook, 1989.

Chapter IV Boston's Other Emerging Industries

In addition to biomedical industries and health services, the private sector industries of computer services, and technology and management business services are technology driven industries with exceptional growth prospects and a very high degree of concentration in the Boston metro area. The high degree of interdependence among these dynamic industries is important to the metro area's future economy. Their individual successes create more business for one another, multiplying employment and business opportunities for the regional economy. Figure 5 shows the location quotients of several growth technology industries in Massachusetts and Metro Boston. A location quotient of 1.00 indicates that an area has the same employment concentration for an industry as the United States as a whole. A quotient higher than 1.00 indicates that an area specializes in that industry. Massachusetts' and Boston's quotients are high in these growth industries.

Private industry sectors delivering the most advanced new products and services to the fastest growing markets include research/management/consulting/testing business services and computer software and services. Computer software and services is the strongest sector considered by a recent Bureau of Labor Statistics study, with 4.9 percent annual job gains projected. The Boston Metropolitan area has nearly three times the national average proportion of total jobs in this industry, and 93 percent of Massachusetts state employment in this industry is in the metro area.

The second fastest growth sector is research-management-consulting-testing business services which has a projected annual rate of employment growth of 3.2 percent. The Boston Metropolitan area has more than 2 1/2 times the national average employment concentration in this industry and 91 percent of the Massachusetts employment in this industry is in the metro area.

Even if we combine all these sectors with biotechnology and medical instruments, they now constitute less than 4 percent of state employment. By the year 2000, however, their combined workforce will have grown by two thirds if they expand at projected national rates.

Unlike the personal computer, the X terminal does not do the actual computing; it is part of a computer network and the computing is dome by a separate, central computer. But like the personal computer, the X terminal allows a user to display multiple "windows," each containing a program, and is controlled with a mouse pointing device. Also it enables the display of sophisticated graphics like pie charts and photographic images. The typical office terminal running off a central computer does not have such versatility.

This development in computing will be favorable to the Massachusetts computer industry for two reasons. First, because Massachusetts firms such as the Digital Equipment Corporation will be entering this market. The second reason is that the Massachusetts electronics industry provides components to the minicomputer and mainframe markets.[2]

Massachusetts Microcomputer Center

The state of Massachusetts has joined with the electronics industry and academia to create a flagship for electronics engineering for the 1990's. The new $52 million Massachusetts Microelectronics Center in Westboro is one of the two or three finest facilities in the country for training integrated-circuit engineers.[3] The Center is sponsored by the Massachusetts Technology Park Corporation and its goal is to lift engineering education to a level that will attract the best and brightest faculty members and insure a well-educated work force for electronics companies in Massachusetts.

In addition to the center's main facility in Westboro, each of ten participating universities has a satellite unit on campus. In the 1988-1989 school year, about 2,500 engineering students worked with the latest in computer-aided design equipment.

The Massachusetts Microelectronics Center was created by the state pledging $20 million in 1982 if industry would match that sum. The electronics industry rose to the occasion donating more than $30 million in cash and equipment. Many companies are eager to donate equipment to a facility that will be used by thousands of potential employees and customers. The center was recognized as one of the 10 Sematech Centers of Excellence. In return for conducting research on semiconductor manufacturing, the center will receive $1 million annually for five years.

a production and distribution facility run by a consortium of software companies which would generate software packages and documentation and distribute them in a shared facility at considerable cost savings to each firm. These cost savings would result from increased productivity in the industry through the economies of scale that would result from the consortium. This would free each business from the production and distribution functions so that these firms can concentrate on the research and development and marketing functions.

Military Technology Transfer

The Massachusetts economy is a long-standing beneficiary of defense spending, and the overall cutback in defense is widely taken to as a threat to the state's economic position. In fiscal 1988, Massachusetts indeed suffered a 17 percent drop in defense contracts, and that trend will continue.

Yet Massachusetts is better situated than most other defense-oriented states. This state is not dependent on a single employers like, Washington state is with Boeing or Maine is with Bath Iron Works. Raytheon, which is Massachusetts largest defense contractor and employees 3100 people in the commonwealth, only relies on the Department of Defense for about one-third of its total revenues.[5]

Massachusetts defense contracts are more oriented toward research and development at double the national rate --with nearly one-third of all contracts for R&D. Similarly, more of this state's defense contracts go to academic laboratories than other states.

In 1986, Congress passed the Technology Transfer Act, which instructs federal commanders to facilitate civilian commercial access to the fruits of Pentagon sponsored R&D. The department of defense has three major research facilities in Massachusetts including; the Army's Natick Laboratories, Air Force Systems Command research facility at Hanscom Air Force Base and the Watertown Arsenal.

The state has been meeting with the Massachusetts Military Coalition, an organization of federal base commanders. The objective of these meetings is to bring the state's military technology transfer officers into an on-going collaboration with the technology licencing operations of MIT and

The mass production of spider silk may someday mean a decline in the cost of commercial silk.

According to Jack Shamash, president of the New-York based Shamash and sons, the country's largest silk importer, the idea that spider silk could replace silkworms silk is "a lot of nonsense".[9]

This is not the first use of high technology in the apparel industry in Massachusetts. In 1984, the Draper Laboratories in Cambridge, was commissioned to develop a robotize computerized factory via telecommunications with retail stores where individual body measurements could be taken to produce made-to-measure clothes for the price of off-the-rack clothes. At about the same time, the Japanese launched a similar effort to accomplish essentially the same task. However, the Japanese had forty times the funding, with the government funding fifty percent and private financing paying for the other fifty percent. Given the funding discrepancy between the two projects it is not difficult which will be the more successful.[10]

A third major development in the textile industry is use of advanced materials for use in fabrics. In a Japanese university a team has had some success using ceramic fibers to create a nearly indestructible as well as potentially fireproof fabric.

The use of biotechnology and advanced materials to produce the fibers and high technology to produce the garments this region could once again become a major producer of textiles. This could happen with the transfer of technology from military laboratories to the civilian marketplace; along with an increase in research and development by the federal government and private industry to improve the existing technology and develop new technologies.

Boston is the home to a number of textile manufacturers and with these advances in biotechnology, ceramics and high technology; the textile industry may be a possible emerging industry and this could make it a candidate for the City of Boston's Technopolis Strategy. This would require a further study of the industry and the potential use of new technology on Boston's indigenous textile firms.

service oriented companies which perform recycling tasks or operate incinerators; nonprofit organizations are establishing recycling programs, as well as monitoring the environmental impact of landfills and proposed incineration projects; state government oversees regulation and planning of solid waste management; and the federal government focuses on research and regulation. A few useful disciplines for aspirants in this field are engineering, environmental science, urban studies and planning, a combination of business, management, and finance.

Recycling

According to Gaylord Nelson, the founder of Earth Day in 1970, "We must transform from a throw-away society to a preserve and recycle society". Recycling is one of the growth industries of the 1990's.

One of the fundamental flaws of our economic system is that the pricing mechanism does not reflect the cost of disposal and the environmental consequences. For example, the retail prices of products containing chlorofluorocarbons (CFC's) such as aerosol cans, polystyrene, halon fire estinguishers, refridgerators, and air conditioning units, in no way account for the environment consequences of ozone depletion. This is an issue that will have to be addressed in the 1990's if we are to preserve the environment for future generations.

Hazardous Waste

The leaking of hazardous waste from landfills into water and air has become the most visible environmental issue in the United States. Since 1980 federal estimates of seriously leaking sites have climbed dramatically.

For example, currently in Massachusetts there are 1,000 hazardous materials sites identified and designated for clean up. This number could increase to as high as 30,000 according to Mr. Russel Sylva, of MFA Environmental, and former Undersecretary for the Massachusetts Executive Office of Environmental Affairs.

At the national level Mr. Sylva reported that the Environmental Protection Agency has estimated the total cost of environmental clean up at $200 billion.

The current Congress is formulating a new version of the Clean Air Act which will also generate new employment as utilities and industrial plants install new equipment to comply with the new regulations. If one is wondering whether this measure will pass one just has think about the amount of air you breath in one day, for example, the average adult breaths 6 liters of air every minute, which translates into 8,640 liters of air per day on average. The clean water act was passed and people only consume 2 liters of water per day on average. The new regulations are designed to reduce emissions of acid rain, urban smog and toxic air pollution.

Currently, the US Government spends $32 billion per year on clean air. Under the proposed changes to the Clean Air Act, the Senate believes we should spend $42 billion more per year, the House would spend $32 billion more per year, and the President thinks we should spend only $20 billion more annually.

Los Angeles is proposing some of the most radical changes to mandate clean air. Starting in the next few years cars and trucks must use cleaner fuels such as ethanol until the year 2010 when cars must run on electric power.

Another radical approach to regulating clean air is using a proposed allowance system. Which will give larger polluters an incentive to clean the air beyond what is required and then sell the excess to smaller firms giving them the right to pollute because they may not be able to afford the cost of scrubbers at the current prices. However, as time passes the regulations will become more stringent and the smaller firms will have to eventually scrub the air and it is hoped that technology will reduce the costs of installing scrubbers.

In 1989, the Bush Administration is calling for $710 million program to research and develop Clean Coal Technology. This research is aimed at reducing the amount of sulfur in coal, which when burned and mixed with water in the atmosphere becomes acid rain.

However, one gas that is not being addressed is carbon dioxide which is a theoretical threat by contributing to global warming through the greenhouse effect. Automobiles are the greatest source of carbon dioxide and in fact one gallon of gasoline produces 5 pounds of carbon dioxide (CO_2). Every year 5.5 billion tons of CO_2 are spewed into the Earths atmosphere.

an accompanying major such as forestry, will aid in seeking employment, as will possession of work experience and relevant technical skills.

Parks and Outdoor Recreation

This is one of the more popular fields of the environmental fields; many of us wanted to become rangers at some point. In addition to traditional rangers, this field includes recreation planners, interpreters, administrators, natural resource managers, and research and maintenance staff. Only a small percentage of employment is within the National Park Service. Other federal agencies, state and local park systems, and private nature centers provide the majority of jobs. Demand for outdoor recreation continues to climb, impart because more and more people live in urban areas and want recreation closer to home. Also, an aging population with more free time wants to use recreational areas year round not just for hiking, but for other activities, such as exercising and learning. Consequently, park professionals have to deal with a variety of complicated multiple-use issues. Balancing recreation and preservation tops the list. The field can be tough to break into, and seasonal and volunteer work is an absolute necessity. Beyond experience, interpersonal skills combined with some background in hard sciences are the next most important prerequisites. Be prepared to relocate often in your career.

Forestry

The days of foresters who spend most of their time in the field are over. The field now employs professionals with diverse backgrounds and a variety of forestry-related specialties. The Society of American Foresters lists over 700 types of jobs in forestry, many of them for specialists such as forest economists or forest hydrologists. Increasingly, foresters are moving out of the forest and into the office.

There is an emphasis on multiple uses of the forest as recreational area, watershed, fish and wildlife habitat, and source of timber. The fastest growing demand is for foresters to stem the decline of U.S. urban forests. Finally, foresters are working on issues related to health of forests (acid rain, smog) and global deforestation. About a third of foresters work for the federal government, a third for state and local governments, and the remainder, a growing percentage of the work force, for

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